AKARI near- and mid-infrared slitless spectroscopic catalogue

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ABSTRACT

We present the current status of the *AKARI* slitless spectroscopic catalogue, which is produced as a part of the *AKARI* data archive activities. *AKARI* has capability of slitless spectroscopy in the NIR and MIR wavelengths for a $10' \times 10'$ area. The data reduction is, however, very difficult due to a confusion of nearby sources after dispersion. In order to solve the problem, we first make a point source list in each FOV from the reference image, and evaluate overlaps between the spectra based on their positions and fluxes. As a trial, we applied the procedure to the Phase 2 MIR-S data (5–13 μm). As a result of processing all reference images of 884 spectroscopic observations, 42,000 point sources (at $\lambda = 9$ μm) are extracted with a detection limit of 0.3 mJy. Based on the source list, we identified the non-overlapped sources and extracted their spectra. We obtained MIR spectra of 880 objects including main sequence stars, AGB stars, galaxies, and AGNs. The dataset is valuable as an unbiased spectral sample in the MIR. The point source and spectroscopic catalogues will be publicly released in the near future.

Keywords: stars: general, galaxies: general, infrared: galaxies, infrared: ISM, infrared: stars

1. INTRODUCTION

AKARI/IRC (Murakami et al. 2007; Onaka et al. 2007) has slitless spectroscopic capability in near-infrared (NIR; 2.5–5.0 μm) and mid-infrared (MIR; 5–13 μm and 18–26 μm). In slitless spectroscopy, all the point sources in the FOV are dispersed at one time. Slitless spectroscopy is, therefore, suitable for making unbiased sample and serendipitous survey. However, there is a big issue on the slitless spectroscopy. That is confusion of nearby sources after dispersion. If there are only a few bright sources in a FOV, overlap may be negligible, and we may be able to extract their spectra without overlap. But if there are many bright point sources in a FOV, spectra are confused each other. Hence we need to select uncontaminated point sources, from which we can extract spectra without overlap.

In order to solve the problem, we use information of point sources in the corresponding reference image, which is obtained in all observations to identify the observed position accurately. Since we know how a point source is dispersed on the detector, we can check overlap after dispersion from positions of point sources in the reference image. There are three channels in the *AKARI*/IRC depending on the observed wavelength; NIR, MIR-S, and MIR-L. In the NIR channel, many point sources are expected to be detected, which means that images would be heavily confused. Since only MIR-L has different field of view among the channels, comparison with other data is relatively difficult in the MIR-L data. Hence we apply the above analysis procedure to the MIR-S slitless data as a trial. NIR data will be analyzed in the next step using techniques obtained from the analysis of MIR-S data.

2. DATA REDUCTION

We analyzed all the 884 data for Phase 2 MIR-S slitless spectroscopy. MIR-S channel covers the wavelength range from 5.5 μm to 12.5 μm using two dispersers, SG1 and SG2. The spectral resolution is $R = \lambda/\Delta\lambda = 50$. Figure 1 shows observed areas on the sky, and the number of observations as a function of Galactic latitude.

Figure 2 shows the demonstration of the data reduction in an example field. Overall data reduction is roughly divided into the following three steps. First, we perform point source extraction for calibrated 9 μm reference images analyzed by Egusa et al. (2016). We used DAOPHOTO in the IDL Astronomy User's Library assuming Gaussian PSF (FWHM: $6''.0$). For every identified source, we performed photometry, and estimate their flux.

Next, we select uncontaminated sources from the point sources extracted in the first step by three criteria. First, sources only in the green box are selected. Since light from a point source is dispersed along the vertical direction, we cannot

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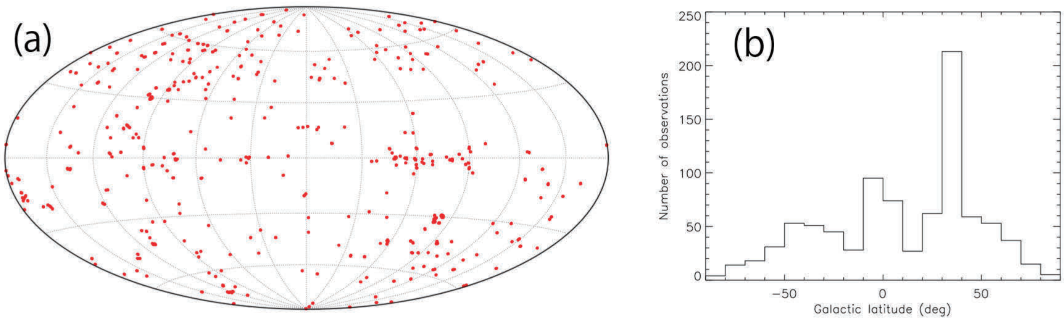

Figure 1. (a) Observed positions on the sky in Galactic coordinate. (b) Number of observations as a function of Galactic latitude.

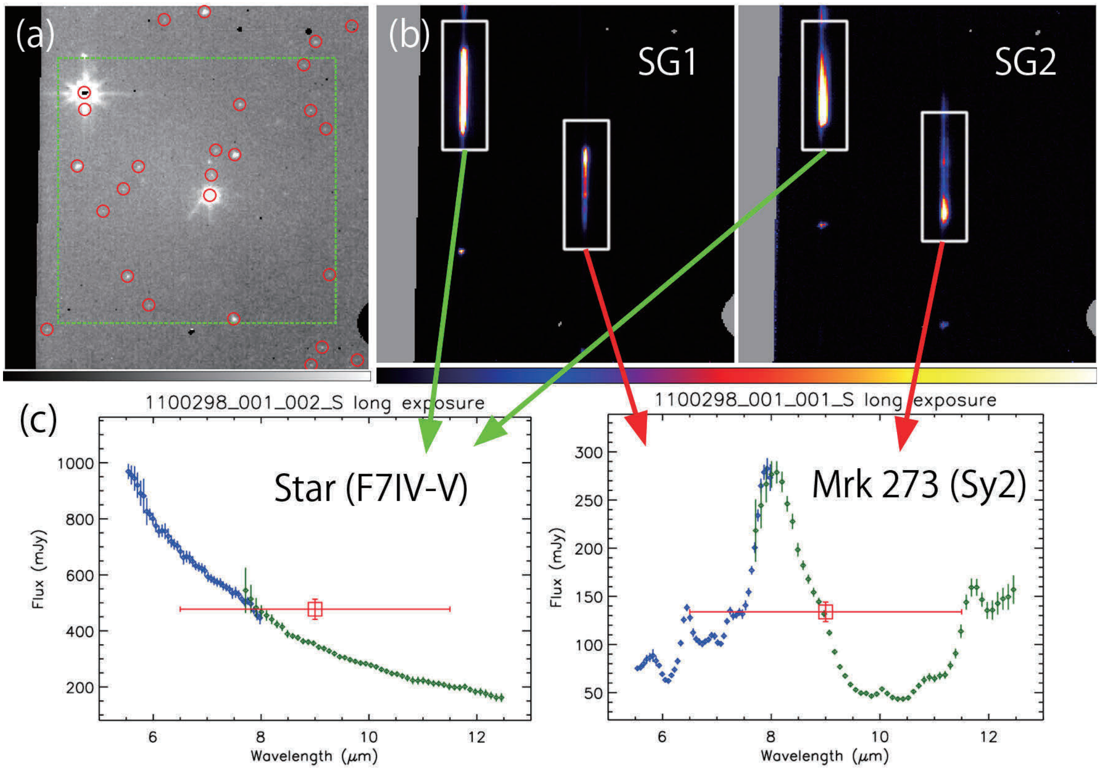

Figure 2. Schematic view of the data reduction processes. (a) Identification of point sources in a reference image. (b) Processing of official spectroscopic toolkit. (c) Extracted spectra.

extract spectra with the full wavelength coverage from sources at edges of the FOV. Next, sources brighter than 1.5 mJy (at 9 μm) are selected. This flux corresponds to 5σ sensitivity of the MIR-S spectroscopy. Finally, we select uncontaminated sources which do not overlap with nearby sources after dispersion. We define an area around a source which is required to extract a spectrum including a sky region, and evaluate overlaps between these areas one by one. As an exceptional case, if the source flux is more than 20 times brighter than those of nearby sources, the overlap is accepted.

Finally, we extract spectra from the uncontaminated sources using the official spectroscopic toolkit. In the example field in Figure 2, spectra from two objects are extracted. We found that these objects are F7 type star and Seyfert galaxy Mrk 273 by the identification using SIMBAD.

3. **RESULT**

We processed all the slitless data, and extracted 893 spectra of 625 objects in total. Figure 3 shows examples of spectra for various object types (e.g., Seyfert galaxy, star-forming galaxy, YSO, AGB star). In the case of intended MIR-S observations, the target is allocated at the center of the FOV as Mrk 273 in Figure 2. Therefore, we can check whether each object is originally intended one or not based on the position in the FOV. In Figure 3, objects labeled in red are originally intended objects by the observer, while objects labeled in blue are serendipitously measured in our analysis. We, therefore, detected many serendipitous objects. This is a merit of unbiased observation using slitless spectroscopy.

In addition to the spectral catalogue, we also obtained 9 μm point source catalogue from a point source list in each FOV. About 42,000 sources in 24 deg^2 are catalogued, and the detection limit is 0.3 mJy, which is 3 times deeper than that of

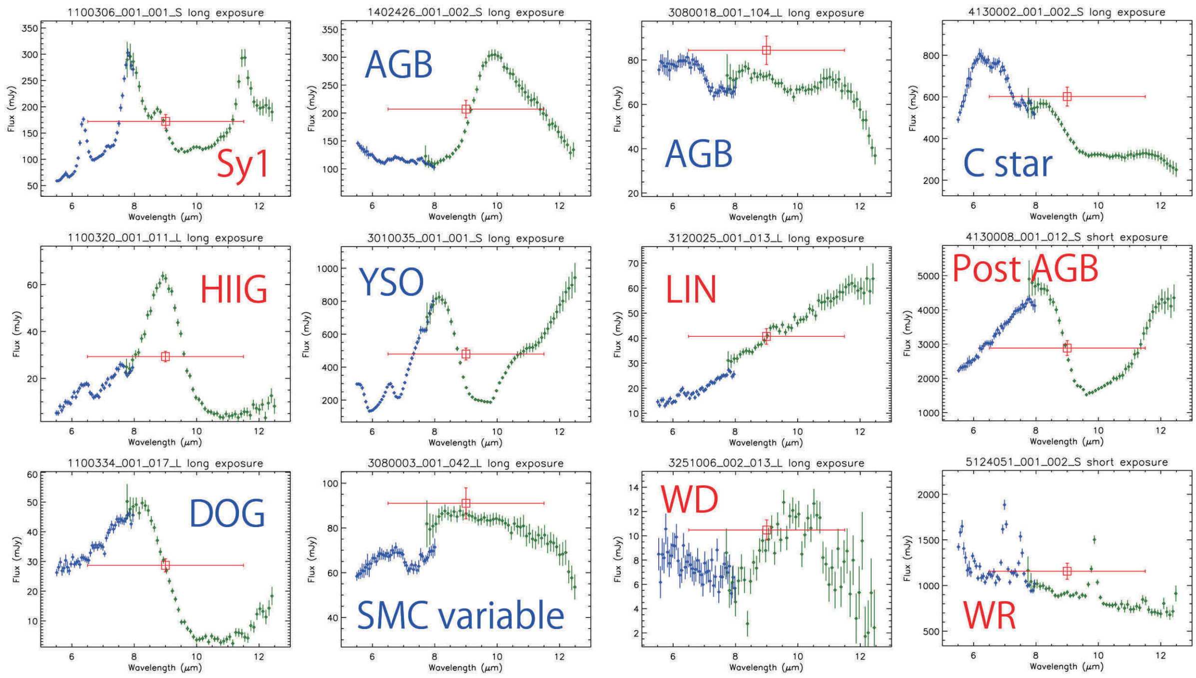

Figure 3. Examples of the extracted slitless spectra with classification of objects by SIMBAD. Data points at 9 μm are fluxes measured from the reference images. Objects in red are originally intended objects by the observer, while objects in blue are serendipitous objects detected in the present study.

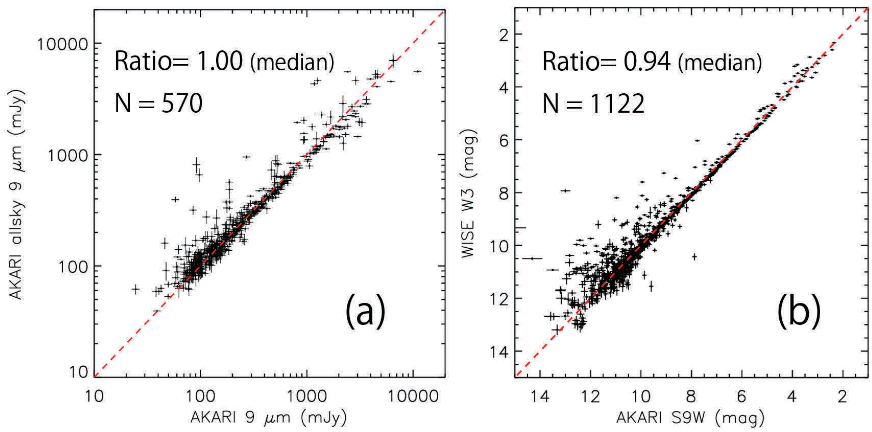

Figure 4. Comparison of fluxes measured from the reference images with those from the *AKARI* and *WISE* all-sky surveys.

the *WISE W*3 band. This by-product catalogue itself is valuable for science. Details of characterization of this catalogue are given by Mizuki et al. in this volume. Here we mention only the calibration accuracy. Figure 4 shows the comparison of fluxes measured from the reference images with those from the *AKARI* and *WISE* all-sky surveys. Since the 9 μm filter used in the reference image and the *AKARI* all-sky survey is identical, we can directly compare the fluxes between our data with the *AKARI* all-sky survey data. In the case of *WISE*, we compare fluxes only for stars identified by SIMBAD in the magnitude unit. The 9 μm fluxes measured from the reference images are well calibrated between 1 mJy (13 mag) to 10 Jy.

4. DISCUSSION

4.1. Object identification

We roughly classify 625 objects detected by the slitless spectroscopy using SIMBAD. As a result, stars are dominant (34%), and other galactic objects (AGB, YSO, etc.;12%) and extragalactic objects (star-forming galaxies, AGN, etc.; 8%) are minor part. We find that 288 objects (46%) are non-identified objects. We also perform cross matching between the 9 μm catalogue with the 2MASS and *WISE* catalogues, and found that 97% of objects have counterpart. For example, the object in Figure 5 is not in SIMBAD, but has a counterpart in 2MASS, *WISE*, and SDSS. From its clear PAH features with small wavelength shift, we identify that this object may be a star-forming galaxy at $z \sim 0.1$. SDSS optical spectroscopy determined its redshift as z = 0.112, which is consistent with the observed wavelength of the PAH features. Hence large fraction of the non-identified objects may minor objects, which have not been studied in detail in IR.

4.2. Comparison with *Spitzer*/IRS spectra

Figure 6 shows the comparison between our slitless spectra and *Spitzer*/IRS spectra for commonly observed galaxies. The *Spitzer*/IRS spectra are retrieved from the *Spitzer* Heritage Archive. As shown in Figure 6, the *AKARI* and *Spitzer* spectra are roughly consistent, although there are small gaps especially around 10 μm. These gaps may be due to the difference in spatial scales used to extract spectra (i.e., *AKARI*: entire galaxies, *Spitzer*: only center of galaxies).

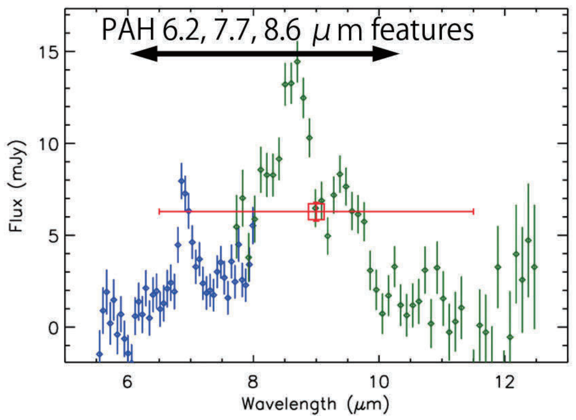

Figure 5. Spectrum of a object which does not have any counter part in SIMBAD.

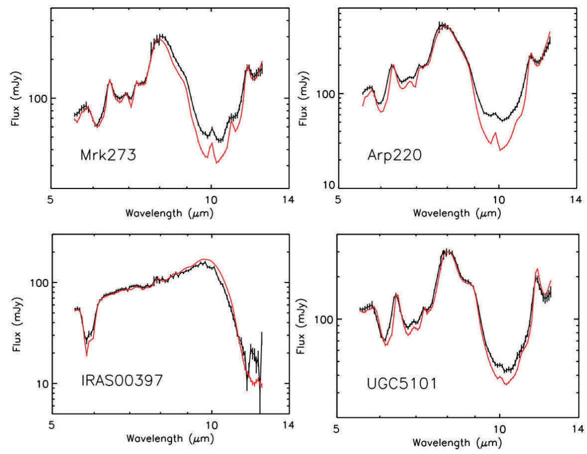

Figure 6. Comparison between *AKARI* slitless spectra (black) and *Spitzer*/IRS spectra (red). *Spitzer* spectra are scaled to match to *AKARI* spectra at 8 μm to compare differences in spectral features.

5. DATA RELEASE PLAN

New slitless spectroscopic catalogue and 9 μm point source catalogue are valuable data set in MIR. Public release is planed after the evaluation and acceptance of the corresponding peer-reviewed science paper.

6. SUMMARY

We have analyzed AKAIR/IRC MIR-S slitless spectroscopic data to obtain an unbiased spectroscopic catalogue. We made point source lists from the reference images, and selected uncontaminated sources, from which we can extract spectra without source confusion after dispersion. 893 spectra of 625 objects are extracted, which are valuable as an unbiased spectroscopic data set in MIR. The objects are classified in stars (34%), other Galactic objects (12%), extragalactic objects (8%), and unknown (46%). The spectroscopic catalogue and 9 μm point source catalogue will be publicly released in the near future.

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